ORIGINAL ARTICLE

ONLINE FIRST

Surgeons' Stress From Surgery and Night Duty

A Multi-institutional Study

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Objective: To examine the stress experienced by surgeons in response to surgery and night duty.

Design: Analyses were done by subjective questionnaires and an objective urine analysis.

Setting: One university hospital and 15 community/public hospitals in Kitakyushu City, Japan.

Participants: Sixty-six Japanese surgeons.

Main Outcome Measures: Scores on the NASA Task Load Index and Stress Arousal Checklist and urine biopyrin levels.

Results: The Task Load Index score significantly increased in association with the duration of surgery and the amount of surgical blood loss. Urine biopyrin levels significantly increased with the duration of surgery. Night duty significantly decreased sleep time and significantly increased urine biopyrin levels. Stress Arousal Checklist Arousal Scale scores significantly decreased the morning after night duty and the evening after the end of the following day shift.

Conclusion: Surgery was associated with stress on surgeons and night duty influenced the arousal of the surgeons during the day shift following night duty.

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THE NUMBER OF YOUNG DOCtors who want to be surgeons has decreased recently, with the rate in 2000 declining to 80% of that in the 1980s. One of the reasons is the unfavorable working conditions experienced by surgeons, which has led to a decrease in the number of surgeons and, in turn, has caused even greater increases in the surgeons' workload and risk of errors. It has therefore become a vicious circle. The majority of the surgeons' work is in surgery and on night duty. The effect of surgical stress on patients has been widely studied, while, to our knowledge, the surgeons' stress due to surgery and night duty has not. This study subjectively and objectively examined the stress experienced by surgeons in response to surgery and night duty.

METHODS

A total of 66 Japanese surgeons who work in Kitakyushu City, Japan, were enrolled in this study (**Table 1**). The participating institutions were 1 university hospital and 15 community/public hospitals, including 9 teaching hospitals. The hospitals have more than 300 beds, are considered to be representative of the local area, and are secondary or tertiary hospitals. Surgical staff levels are sufficient and levels of surgical treatment are almost similar. Most of the operations were scheduled; few were emergent. One to 15 surgeons from each institution participated. This series consisted of surgeons who were interested in this study and participated voluntarily. The percentages of available data obtained were comparatively high (**Table 2**).

See Invited Critique at end of article

Analyses were done by subjective questionnaires and an objective urine analysis. The Stress Arousal Checklist (SACL) and NASA Task Load Index (TLX) were the questionnaires used for this study. The objective analysis was done by the measurement of biopyrin in the urine.

The SACL, which is a subjective measurement for stress and arousal levels, was developed by Mackay et al[1] in 1978. The new Japanese version of SACL[2] was used in this study. The checklist includes a Stress

Table 1. Characteristics of Participating Surgeons

Characteristic	No. of Surgeons
Sex	
M	65
F	1
Age, y, mean (SD) [range]	38.4 (9.2) [26-61]
26-29	13
30-39	19
40-49	18
≥50	8
Unknown	8

Table 2. Number of Participating Surgeons and Available Data Obtained

Code of Institute	No. of Participating Surgeons	Available Data Obtained, %
A	15	90.7
B	9	95.6
C	5	100.0
D	5	92.0
E	4	100.0
F	4	70.0
G	4	100.0
H	4	95.0
I	3	40.0
J	3	86.7
K	2	100.0
L	2	100.0
M	2	80.0
N	2	100.0
O	1	100.0
P	1	100.0
Total	**66**	90.6

Scale, reflecting individual perceptions about physical and psychological conditions, and an Arousal Scale, reflecting physical activities, especially autonomic nervous activity. It has 17 adjectives relating to perceived stress and 13 relating to arousal for a total of 30 questions. Surgeons responded to each adjective on a 4-point scale. The total scores of the Stress and Arousal scales were respectively calculated, and high scores meant high mood scores for the Stress Scale and high concentration, attention, or judgment level for the Arousal Scale. The SACL was conducted the morning of the surgical day and after the operation (**Figure 1**) for the analysis of surgical stress on surgeons and in the evening before night duty and in the morning and the evening of the following surgical day for the analysis of night duty stress (**Figure 2**).

The TLX was developed in NASA Ames Research Center in the United States and evaluates the mental workload.[3] It assesses workload on five 7-point scales. High, medium, and low estimates for each point result in a total score range of 21, where 0 is very low and 21 is very high. The TLX contains 6 items: mental demand (How mentally demanding was the task?), physical demand (How physically demanding was the surement for stress and arousal levels, was developed by Mackay et al[1] in 1978. The new Japanese version of SACL[2] task?), temporal demand (How hurried or rushed was the pace of the task?), performance (How successful were you in accomplishing what you were asked to do?), effort (How hard did you have to work to accomplish your level of perfor-

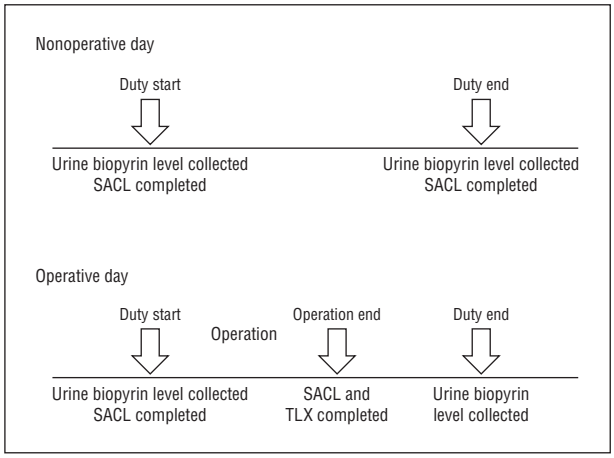

Figure 1. Data collection for analysis of surgical stress on surgeons. SACL indicates Stess Arousal Checklist; TLX, NASA Task Load Index.

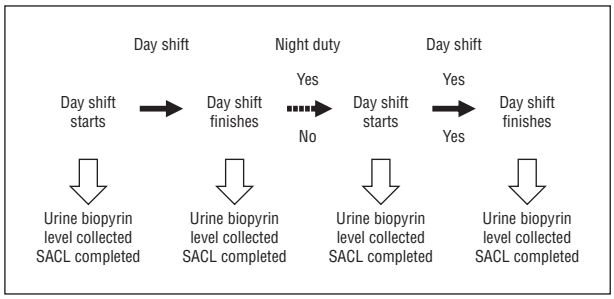

Figure 2. Data collection for analysis of night duty stress on surgeons. SACL indicates Stress Arousal Checklist.

mance?), and frustration (How insecure, discouraged, irritated, stressed, and annoyed were you?). The TLX was given to the surgeons after they finished the operation to determine surgical stress levels.

Urine biopyrin level was measured to assess the stress objectively. Serum bilirubin acts as a scavenger of oxidative stress and is metabolized and delivered into the urine as a metabolite of biopyrin. Urine biopyrin levels reflect oxidative stress levels. The mean (SD) urine biopyrin level of the 62 Japanese surgeons was 1.57 (0.89) U/g of creatine in the morning and that of volunteers whose age and sex distribution corresponded to the 62 surgeons was 1.46 (0.71) U/g of creatine (P=.72). Urine was obtained in the morning and the evening of surgical days for the analysis of surgical stress on surgeons. Urine was obtained in the evening before the surgical day and in the morning and the evening of the surgical day whether they had had night duty or not for the analysis of night duty stress.

This series included 66 Japanese attending surgeons who worked in 16 hospitals in Kitakyushu. Sixty-five were male and 1 was female, with a mean age of 38.4 years (range, 26-61 years) (Table 1). Thirteen were in their 20s, 19 were in their 30s, 18 were in their 40s, 8 were 50 years or older, and the remaining 8 were of unknown age. A total of 912 completed SACL questionnaires, 251 completed TLX questionnaires, and 1030 urine samples were obtained from the 66 surgeons.

The evaluation of stress by operation is shown in Figure 1. Urine was collected and the SACL was completed when duty started. On the nonoperative day, urine was collected and the SACL was completed just before duty ended. On the operative day, the SACL and TLX were completed just after the operations were finished. Urine was collected when duty ended, the

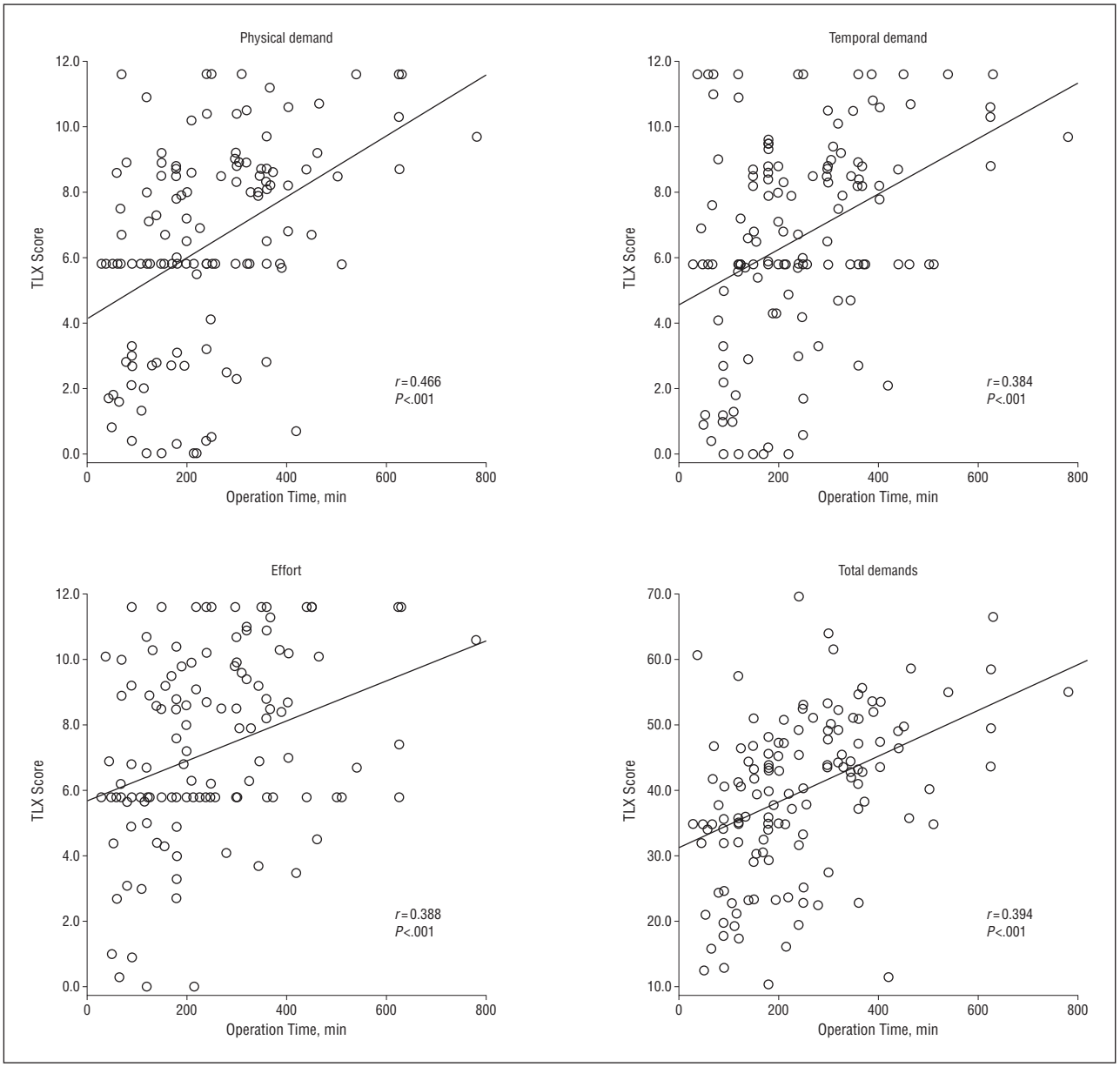

Figure 3. Operation time and NASA Task Load Index (TLX) score. *P* values were determined by Pearson χ^2 test.

same as on the nonoperative day, because it was difficult to collect urine just after operation.

The evaluation of stress by night duty is shown in Figure 2. Urine was collected and the SACL was completed when duty ended before night duty and at duty start after the following night duty. The differences were used for the evaluation of stress by night duty. The data before and after night duty were all obtainable. All participating surgeons continued to work after night duty.

The changes in urine biopyrin levels and TLX scores were compared by the presence or absence of an operation, the number of operations per day, the number of operations as a surgeon, endoscopic or open surgery, duration of operation, and perioperative blood loss. The duration of operation was a period from a skin incision to wound closure and was the total period of each operating time when there was more than 1 operation. Sleep time was self-reported and changes in urine biopyrin levels and SACL scores were compared between the presence and absence of night duty.

Normal distribution was examined by the Shapiro-Wilk test. The statistical analyses were done using the Pearson χ^2 test and 2-sample *t* test. $P<.05$ was considered to be statistically significant.

RESULTS

SURGICAL STRESS AND SURGEONS

The TLX and SACL scores were compared before and after operation (**Figures 3**, **4**, **5**, and **6**). As an objective parameter, urine biopyrin level was measured before and after operation.

The TLX score after the operation showed that stress increased with the duration of the surgery (Figure 3) and with the amount of surgical blood loss (Figure 4) (**Table 3**). There was a significant association between

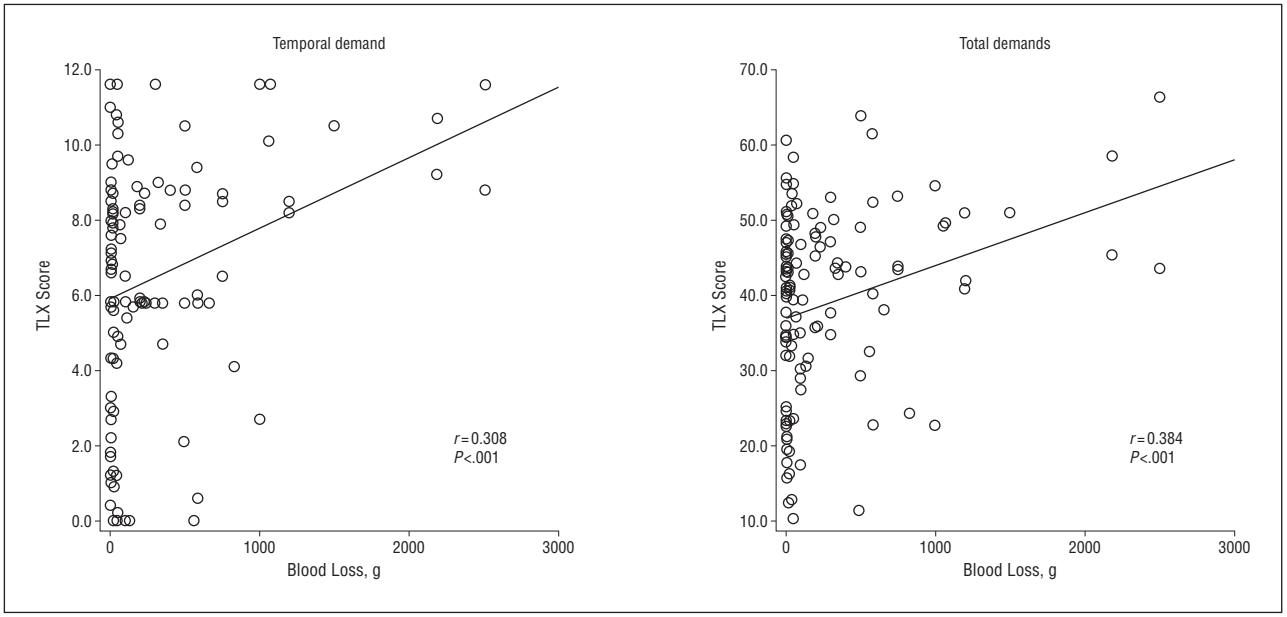

Figure 4. Operative blood loss and NASA Task Load Index (TLX) score. *P* values were determined by Pearson χ^2 test.

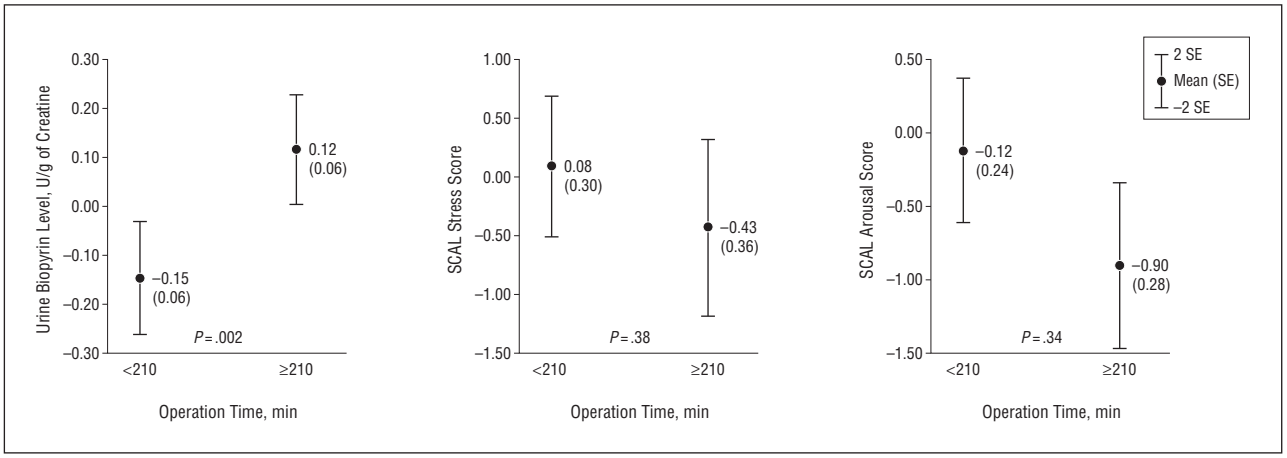

Figure 5. Changes in urine biopyrin levels and Stress Arousal Checklist (SACL) score after operation by operation time. *P* values were determined by 2-sample *t* test.

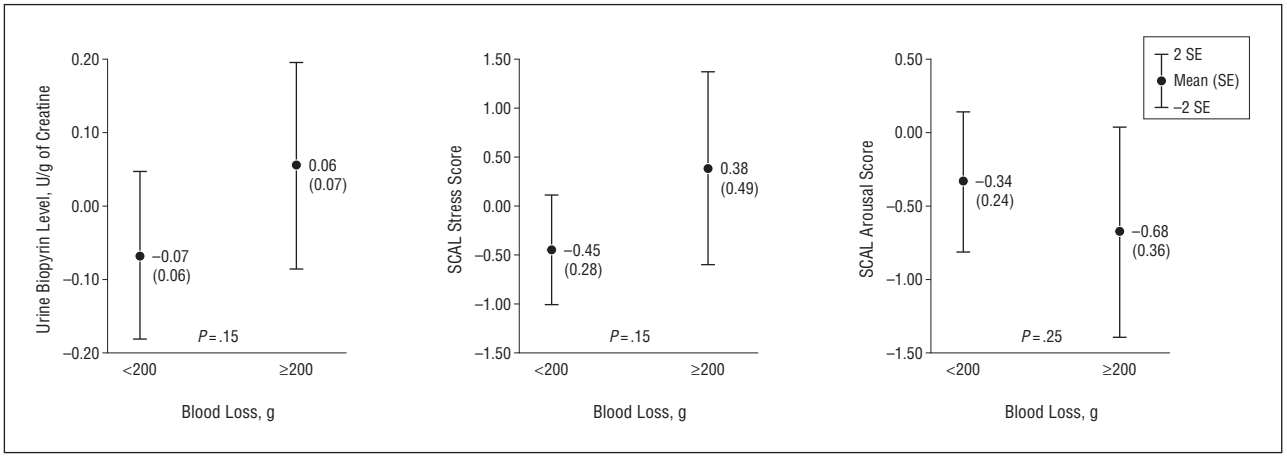

Figure 6. Changes in urine biopyrin levels and Stress Arousal Checklist (SACL) score after operation by amount of operative blood loss. *P* values were determined by 2-sample *t* test.

Table 3. Correlation Between NASA Task Load Index Score, Operation Time, and Amount of Perioperative Blood Loss[a]

	Mental Demand	Physical Demand	Temporal Demand	Performance	Effort	Frustration	Total Demands
Duration of surgery							
r Value	0.174	0.416	0.384	0.119	0.338	0.146	0.394
P value	.04	<.001	<.001	.16	<.001	.09	<.001
Blood loss							
r Value	0.264	0.221	0.308	0.078	0.190	0.160	0.302
P value	.003	.01	<.001	.39	.03	.07	.001

[a] Determined by Pearson χ^2 test.

Table 4. NASA Task Load Index Score by Number of Operations, Operations as a Surgeon, and Endoscopic Surgery

	Mental Demand		Physical Demand		Temporal Demand		Performance		Effort		Frustration		Total Demands	
	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]
No. of operations/d														
1 (n=101)	6.62 (3.23)	.07	5.92 (3.13)	.004	6.37 (3.38)	.10	7.41 (2.77)	.81	7.20 (2.86)	.95	4.64 (3.14)	.39	38.17 (12.44)	.03
≥2 (n=47)	8.79 (7.66)		7.44 (2.84)		7.23 (2.73)		7.51 (2.13)		7.23 (2.54)		5.10 (2.93)		43.30 (13.48)	
No. of operations as a surgeon/d														
0 (n=74)	7.11 (6.66)	.65	6.30 (3.20)	.68	6.32 (3.17)	.23	7.08 (2.81)	.09	6.81 (2.77)	.07	4.86 (3.22)	.76	38.49 (12.91)	.22
≥1 (n=74)	7.50 (2.97)		6.51 (3.03)		6.96 (3.23)		7.81 (2.28)		7.62 (2.69)		4.71 (2.93)		41.11 (12.96)	
Endoscopic surgery														
No (n=83)	7.53 (6.16)	.51	6.40 (2.98)	.96	6.59 (2.98)	.82	7.40 (2.50)	.83	6.95 (2.64)	.19	4.95 (2.91)	.48	39.81 (12.99)	.99
Yes (n=65)	7.01 (3.46)		6.42 (3.29)		6.71 (3.49)		7.49 (2.69)		7.55 (2.87)		4.58 (3.28)		39.77 (13.02)	

[a] Determined by 2-sample *t* test.

the duration of the surgery and TLX score and between the amount of surgical blood loss and TLX score, although the correlations were weak. There were no significant associations between surgical stress and number of operations per day, number of operations as a surgeon, number of operations as an assistant, or laparoscopic or conventional surgery (**Table 4**).

The SACL scores showed that arousal significantly decreased with the duration of the surgery (Figure 5) and stress increased with the amount of surgical blood loss (Figure 6). There were no significant associations between surgical stress measured by SACL and number of operations per day, number of operations as a surgeon, or laparoscopic or conventional surgery (**Table 5**).

The mean operating time was 210 minutes, so 210 minutes was used as a cutoff. Serial urine biopyrin examination showed that urine biopyrin levels were significantly elevated after an operation when the duration of the surgery was 210 minutes or more vs 209 minutes or less. Urine biopyrin levels increased after an operation when the blood loss was 200 g or more. There was no significant association between the changes in urine biopyrin levels before and after an operation and the number of operations per day, the number of operations as a surgeon per day, or laparoscopic or conventional surgery.

NIGHT DUTY STRESS AND SURGEONS

Sleep time was significantly decreased when the surgeons had night duty (**Figure 7**). The SACL scores showed that surgeons were less aroused after night duty, although this was not significant (**Figure 8**). Urine biopyrin levels were significantly elevated the morning after night duty (Figure 8). The surgeons were also significantly less aroused when they finished the day shift following night duty in comparison with when they did not have night duty (**Figure 9**).

COMMENT

The stress from surgery and night duty was examined using subjective questionnaires (SACL and TLX) and objective urine biopyrin levels in a total of 66 Japanese surgeons. Surgeons' surgical stress increased in association with the duration of surgery and the amount of surgical blood loss. Night duty significantly decreased the sleep time of surgeons and decreased arousal the morning after night duty and the evening following the day shift.

This study examined stress surgeons experienced due to surgery and night duty using 2 questionnaires, TLX and SACL. The TLX is used to assess workload. The SACL is used to evaluate subjective stress and arousal levels of workers. The TLX score increased corresponding to the duration of surgery and the amount of surgical blood loss. The SACL showed a significant decrease in arousal the morning after night duty and the evening following the day shift. The SACL score showed a decline in arousal after night duty and the day shift but

Table 5. Changes in Urine Biopyrin Level and SACL Score at the Time of Duty Start and End

	Urine Biopyrin Level, U/g of Creatine						SACL Stress Score						SACL Arousal Score					
	Duty Start		Duty/Operation End		Difference		Duty Start		Duty/Operation End		Difference		Duty Start		Duty/Operation End		Difference	
	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]	Mean (SD)	*P* Value[a]
No. of operations/d																		
1 (n=110)	1.48 (0.73)	.11	1.42 (0.76)	.45	−0.07 (0.52)	.29	6.10 (3.00)	.02	6.14 (3.00)	.41	0.04 (2.84)	.19	6.12 (2.62)	.01	5.49 (2.39)	.06	−0.63 (2.21)	.36
≥2 (n=48)	1.32 (0.54)		1.34 (0.54)		0.02 (0.45)		7.17 (2.55)		6.54 (2.75)		−0.63 (2.92)		5.02 (2.09)		4.75 (2.11)		−0.27 (2.32)	
No. of operations as a surgeon/d																		
0 (n=83)	1.49 (0.74)	.40	1.44 (0.70)	.47	−0.05 (0.54)	.89	6.57 (3.00)	.45	6.17 (2.74)	.94	0.40 (2.40)	.40	5.59 (2.45)	.27	4.89 (2.44)	.03	−0.70 (2.30)	.33
≥1 (n=68)	1.40 (0.61)		1.36 (0.69)		−0.04 (0.46)		6.21 (2.85)		6.21 (3.16)		0.00 (3.40)		6.06 (2.65)		5.72 (2.17)		−0.34 (2.20)	
Endoscopic surgery																		
No (n=93)	1.36 (0.63)	.09	1.32 (0.69)	.09	−0.04 (0.42)	.99	6.37 (2.67)	.78	6.15 (2.81)	.59	−0.22 (2.79)	.79	5.56 (2.36)	.19	5.22 (2.26)	.76	−0.34 (2.11)	.25
Yes (n=66)	1.55 (0.74)		1.51 (0.71)		−0.04 (0.60)		6.50 (3.24)		6.41 (3.07)		−0.09 (3.00)		6.11 (2.71)		5.33 (2.43)		−0.77 (2.41)	
Blood loss, g																		
<200 (n=89)	1.51 (0.74)	.497	1.44 (0.69)	.78	−0.07 (0.54)	.18	6.49 (2.98)	.67	6.04 (2.97)	.29	−0.45 (2.64)	.15	5.89 (2.41)	.07	5.35 (2.31)	.19	−0.34 (2.26)	.43
≥200 (n=47)	1.42 (0.65)		1.48 (0.81)		0.06 (0.48)		6.26 (3.17)		6.64 (3.17)		0.38 (3.37)		6.60 (2.85)		5.91 (2.40)		−0.68 (2.46)	
Duration of surgery, min																		
<210 (n=75)	1.50 (0.73)	.28	1.36 (0.73)	.25	−0.15 (0.50)	.001	6.31 (2.95)	.56	6.39 (0.631)	.63	0.08 (2.58)	.28	5.68 (2.37)	.31	5.56 (2.33)	.36	−0.12 (2.12)	.04
≥210 (n=73)	1.38 (0.67)		1.49 (0.71)		0.12 (0.48)		6.59 (2.96)		6.15 (3.11)		−0.44 (3.19)		6.11 (2.70)		5.21 (2.34)		−0.90 (2.41)	

Abbreviation: SACL, Stress Arousal Checklist.
[a]Determined by 2-sample *t* test.

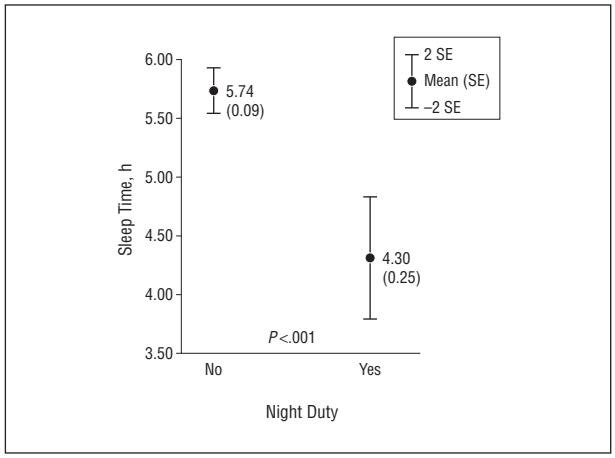

Figure 7. Night duty and sleeping time. The *P* value was determined by 2-sample *t* test.

the differences were not significant. This may be because we did not examine the details of night duty and the day shift. These 2 tests were also useful in assessing the task load and evaluating stress and arousal in the present study.

Bilirubin is biosynthesized from heme and catalyzed by heme oxygenase and biliverdin reductase. Bilirubin is a harmful and useless substance in the body. However, in contrast to its toxic effects, Stocker et al[4] reported that bilirubin can act as a powerful antioxidant in vitro. Biopyrin is one of the bilirubin oxidative metabolites in urine and its urinary concentrations are increased in patients with sepsis[5] and after surgical stress.[6] Some studies have suggested that psychological stress induces the production of reactive oxygen species[7,8] and increased biopyrin levels in social stress in mice[9] and in psychiatric disorders in humans.[10] The surgeons' urine biopyrin levels increased after operation and the increase was correlated with the duration of surgery. Surgeons' urine biopyrin levels also increased the day after night duty and decreased continuously after the following day shift. These findings also support efficacy of urine biopyrin as a marker of physiological and psychological stress.

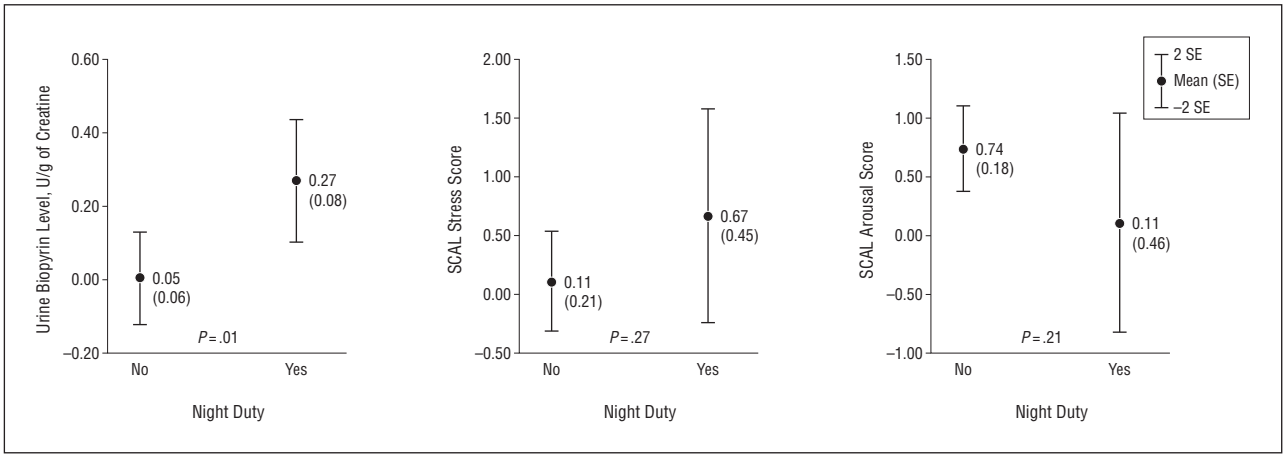

Figure 8. Changes in urine biopyrin levels and Stress Arousal Checklist (SACL) score after night duty vs no night duty. *P* values were determined by 2-sample *t* test.

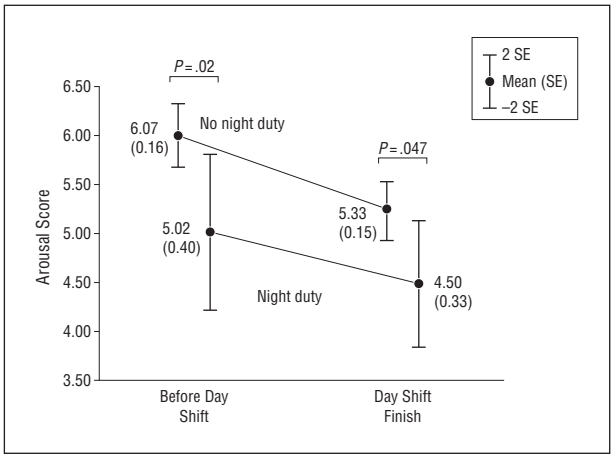

Figure 9. Stress Arousal Checklist Arousal Scale scores after night duty. *P* values were determined by 2-sample *t* test.

The problem of chronic sleep deprivation[11-13] and overwork of surgical residents has become an important issue in the world, including Japan. A combination of poor-quality daytime sleep and increased sleep pressure during the night may result in lowered levels of alertness and an increased risk of errors in people on night duty, such as medical personnel.[13,14] In Japan, surgeons usually work after night duty in most hospitals. The present study demonstrated the stress of night duty on surgeons subjectively and objectively. Surgeons' working conditions, including night duty, should be improved to enhance the quality of life for surgeons, resulting in fewer errors in operations and medical treatment and better medical services for patients.

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INVITED CRITIQUE

Peaceful Rest vs Rest in Peace

With mitigation of trainee stress in the United States, attending surgeons have quietly shouldered increasing responsibilities both in the operating room and nighttime call. In this issue of the *Archives*, Yamaguchi and colleagues use questionnaires and a biochemical marker to explore the effects of the stress of operative work and of nighttime clinical responsibilities on a cohort of attending surgeons. Operative stress and nights on call lead to diminished arousal and to increased excretion of a stress marker. How should the surgical community respond?

In one sense, the American surgical community has already responded. Some attending surgeons decline night and emergency duty. Others demand additional compensation from hospitals or their practice groups to offset the stress. Market forces thus attach a monetary value to the stress, and the American health care system appears willing to absorb the financial cost. Yet money cannot and will not counteract either the adverse effects on patients or the physical toll on their surgeons.

Objective analysis suggests that 24 hours awake impairs performance equivalent to a blood alcohol concentration of 0.10%, a level uniformly regarded as intoxicated with respect to motor vehicle operation.[1,2] Fewer than 6 hours of sleep during night call is associated with increased incidence of complications by attending surgeons.[3] Thus, the ethical issues of continuing to operate after prolonged wakefulness are coming into sharper relief.[4-6] A recent scenario concludes that the sleep-deprived surgeon is ethically obligated to rest before performing further complex procedures.[7] While biomarkers that may someday yield a practical assessment of sleepiness have been identified, the equivalent of a Breathalyzer for drowsiness is unlikely to appear in the near future.[8] We need to make prudent decisions about our own fatigue and consequences to patients.

Less clear is the toll on surgeons' health. Personal experience over a quarter century of trauma and emergency surgical call suggests that frequent night duty alters alertness, metabolism, resistance to ordinary pathogens, and the general sense of well-being. Long-term effects of difficult surgery and sustained night duty on the health and longevity of surgeons are not known but need to be exposed. Indeed, it may not be sleep deprivation per se but rather the repeated circadian disruption and consequent dysregulation of immune responses that lead to chronically impaired health among shift workers.[9]